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The Tension Forces Acting on the Belt Conveyor Rollers

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Abstract: This article determines the distribution of the forces applied to the cross-sectional surface of the belt, when rocks are transported by belt conveyors, the effect of dynamic forces on the bending of the belt and middle roller length rocks on the basis forces the roller supports.

Keywords: Belt conveyor, belt, roller, roller base, damper, power.

INTRODUCTION

Vehicles used in the mining industry must have high production productivity, high capacity and durability, and ensure uninterrupted delivery of minerals over significant long distances.

One of the most efficient types of continuous transport machines is belt conveyors because they transport minerals over long distances with minimal labor and energy costs.

Determining the effect of gravity on the belt conveyor rollers and the distribution of forces will depend on the dimensions of the roller, the angle of inclination of the side rollers, the weight of the belt and the mass of rock at 1 m (Fig. 1) [4,5,6,7].

Issues related to the establishment of a rational geometric shape of the roller bearings of linear sections to equalize the loads on the bearings of the side and middle rollers are considered. The ratio between the lengths θ of the middle l_{cp} and side $l_{б}$ rollers is determined, at which the cross-sectional area of the load reaches a maximum (Fig. 1). A load lying on a belt of width B occupies the working width $B = 0{,}95 \div 0{,}005$ (m) on it. The side rollers are set at an angle β. The cross-sectional area of the load on the belt consists of two areas: a trapezoid F_2 and a segment of a parabola F_1 with an angle φ at the base equal to the angle of repose of the load on the moving belt.

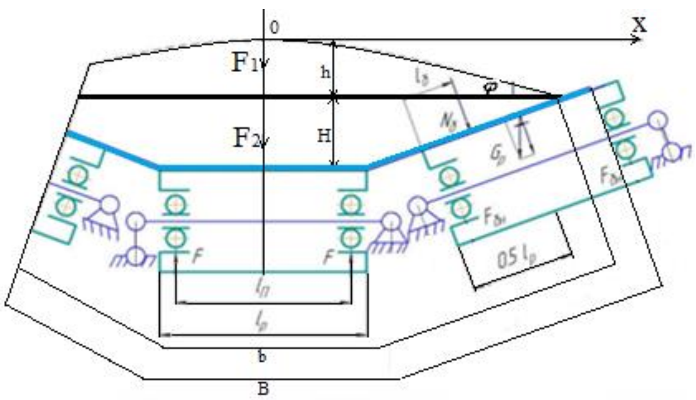

Fig.1. Basic geometric relationships for the roller bearing of the linear part of the belt

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In accordance with Fig.1, the cross-sectional area of the load

$$F = F_1 + F_2 = \frac{1}{6}a^2 tg\varphi + \frac{(a+b\theta)}{2}\cdot b\left(\frac{1-\theta}{2}\right)\cdot \sin\beta \qquad (1)$$

Using formula (1), the area F was calculated for the angles of repose of the load in motion with $\varphi = 15^0,\ 20^0,\ 25^0$ the angles of inclination of the side rollers $\beta = 30^0, 36^0,\ 45^0$ for a standard row of belts with a width of $B = 1200\,mm$ up to $B = 1800\,mm$ at values of quantity $\theta = 0{,}2; 0{,}25;\ 0{,}3;\ 0{,}35;\ 0{,}4.$

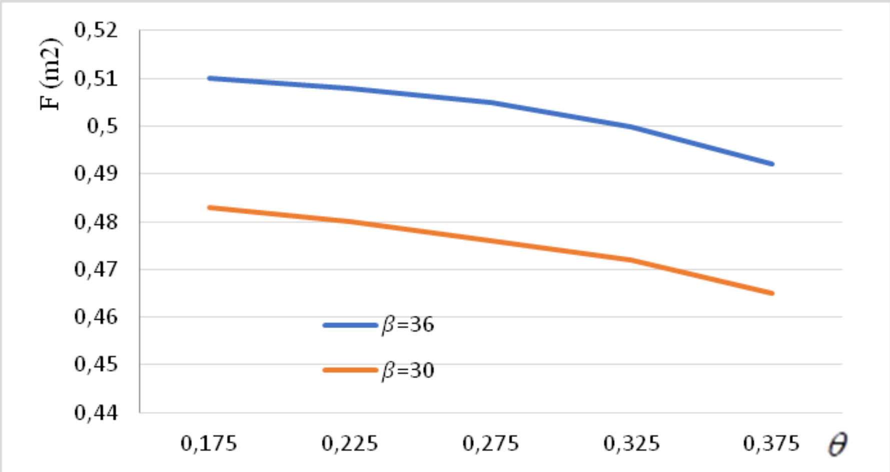


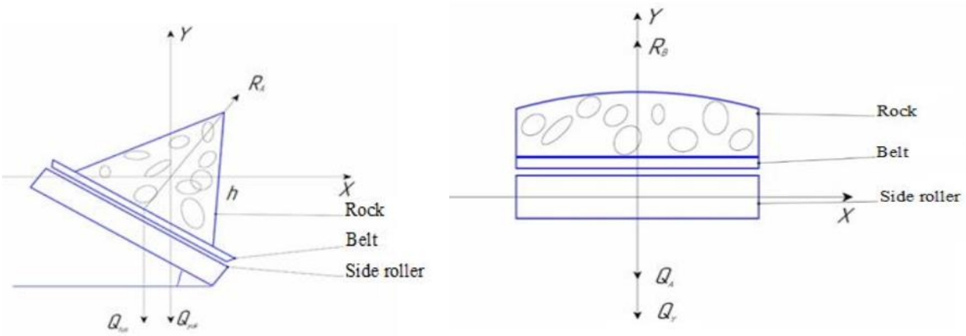
Fig.2. The dependence of the area of the transverse load section from F the coefficient θ

As an example, Fig. 2 shows the dependences cross-sectional area of the F load on a 1800 mm wide belt and the angle of the load $\varphi = 20^0$ on a moving belt.

As you can see, the optimal ratio θ_{onm} at is θ_{onm} approximately equal to 0.3 i.e. with the geometric width of the tape $B = 1800\,mm$ (working width $B = 1550\,mm$) the length of the middle roller is 550 mm, (length of the section $l_p = 450mm$ and length of the side roller $l' = 575mm.$

The belt conveyor transports bulk cargo, for which the theory of bulk media is valid. The paper takes into account that when moving on a conveyor belt, the load is sequentially in two phases: active and passive, and each phase of the load is approximately half the distance between the roller supports [8,9].

Figure 3, a, b shows the cross-sections of the side prism of bulk cargo in the passive phase.



a. b.

Fig.3 Scheme the action of forces in the passive phase of the load:

a - on the side rollers; b - on the middle roller

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So, for example, for the passive phase, the following expressions were obtained in the work: for the reaction of the side roller (Fig. 3a).

$$R_{бр} = \frac{1}{8} g\rho \left(\frac{b-l_p}{2} \right) \xi_n^2, \quad N; \tag{3}$$

where ξ_n - the load passive pressure coefficient.

$$\xi_n = \frac{\sin(\beta-\alpha)}{\sqrt{\sin\beta} - \sqrt{\frac{\sin\alpha \cdot \sin(\alpha+\varphi)}{\sin(\beta+\varphi)}}};$$

ρ - bulk density of cargo, кg/m^3 ;

for the reaction of the middle roller R_{cp} (Fig. 3b).

$$R_{cp} = \frac{1}{4}\rho g \left\{ \frac{1}{6}\left[\theta b + 2b\left(\frac{1-\theta}{2}\right)\cos\beta \right]^2 tg\varphi + \left[\theta b + b\left(\frac{1-\theta}{2}\right)\cos\beta \right] b\left(\frac{1-\theta}{2}\right)\sin\beta \right\} -$$

$$-2\cdot\frac{1}{4} g\rho \left(\frac{b-l_p}{2}\right)^2 \xi_n^2 \cos\beta, \ N; \tag{4}$$

In addition to the forces $R_{бр}$ and R_{cp} forces from the weight of belt and rotating parts of rollers are also taken into account. In this case, additional forces act on the middle roller:

$$P_{cl} = h_l \rho_l g \theta b, \quad P_{cr} = q_0 \theta b, \ N.$$

and on the side roller force:

$$P_{bl} = h_l \rho_l g \left(\frac{1.1b + 0,05 - \theta b}{2} \right) \cos\beta, \quad P_{br} = q_0 \left(\frac{1.1b + 0,25 - \theta b}{2} \right) \cos\beta, \ N.$$

where is h_l the thickness, m; ρ_l - density of material, kg/m^3, ($\rho_l \approx 1200$ kg/ м^3 for fabric and $\rho_l \approx 2000$ kg/ м^3 for cable tapes); q_0 - conditional running weight of the roller: $q_0 = \frac{G_p}{l_p}$, N/m. Similarly, the forces acting on the area of active pressure are defined P_{ba}.

Thus, the resulting force acting on each middle roller bearing is

$$P_{c\Sigma} = \frac{1}{2}\left(P_{cn} + P_{cl} + P_{cr}\right) = \frac{1}{2}\left[\left(\frac{1}{2}P_{cn} + \frac{1}{2}P_{ca} \right) + P_{cl} + P_{cp} \right],$$

on the lower side roller bearing

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$$P_{b\Sigma}=\frac{2}{3}P_{bn}+\frac{1}{2}\left(P_{bn}+P_{br}\right)=\frac{2}{3}\left[\left(\frac{1}{2}P_{bn}+\frac{1}{2}P_{ba}\right)\right]+\frac{1}{2}(P_{bl}+P_{br}),\ N.$$

In accordance with the problem statement, it is necessary that the force to the bearing of the middle roller be equal to the force to the lower bearing of the side roller. On the basis of this ratio, the value is determined in the work θ, at which the fulfillment of the set condition of equality of forces is ensured. $P_{c\Sigma}=P_{b\Sigma}$ So, for example, for a belt conveyor with a belt width of 1800 mm, the value θ is close to 0.3. In this case, the length of the middle roller is $l_{cr}=304\div450mm$, and side $l_b\cong450\div523mm$, while the productivity of the conveyor will increase by about 5-7% (at speed $\vartheta=5m/s$ and $\rho=2{,}2$ t/ m^3, which will be about 1000 t/h). Figure 4 shows the difference in the lengths of the middle and side rollers on the roller bearings, the graph of the dependence of the slope angle of the side roller, and the difference in the lengths of the middle and side rollers as the side roller slope increases.

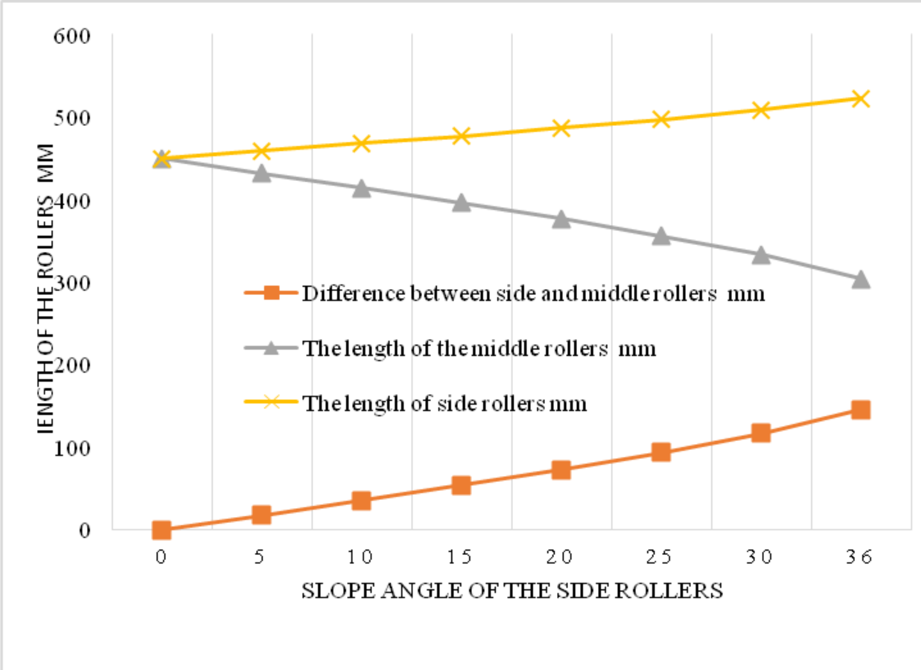

Fig 4. Graphs of dependence on the angle of the lengths of the middle and side rollers

CONCLUSION

The tension on the conveyor belt and rollers was determined on the basis of mathematical developments, the distribution of the belt, side rollers and middle rollers, and the variation of the length dimensions of the belt conveyor support rollers in the range of impact forces, the slope angles of the falling rollers in the range of 0-36^0, the length of the middle roller in the range of 450-304 mm, the length of the side rollers in the range of 450-523 mm.

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